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DRAFT TRANSLATION

PRELIMINARY RESULTS OF INVESTIGATION OF SUN'S X-RAY RADIATION WITH THE HELP OF ROCKETS AND SPACESHIPS

(Predvaritel'nyye rezul'taty issledovaniya rentgenovskogo izlucheniya Solntsa s pomoshch'yu raket i kosmicheskih korabley).

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ABSTRACT

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The present work deals briefly with the preliminary results of investigations of Sun's X-ray radiation in the region of spectrum shorter than 10 Å, carried out during two vertical geophysical rocket launchings to 105 km on 21 July 1959, and during the flights of the second and third spaceships on 19-20 August (perigee at 305 km, apogee at 320 km), and on 1-2 December 1960 (perigee at 180 km, apogee at 249 km).

COVER-TO-COVER TRANSLATION

The investigation of the Sun's shortwave radiation absorbed by the terrestrial atmosphere offers a substantial interest for many questions of solar physics and geophysics. Of essential interest is the study of the shortwave edge of the solar spectrum extending to the region of several ångströms. This radiation originates from the hottest parts of the solar corona, and it is subject to quick variations linked with the dynamics of still obscure physical processes taking place in the outer envelopes of the Sun. It also penetrates the terrestrial atmosphere to utmost depths and plays a substantial part in the formation of the lower ionosphere layers.

The theoretical investigation of the Sun's shortwave radiation was carried out by I. S. Shklovskiy [1], and then by De Jager and Elwert [2], T. V. Kazachevskaya and G. S. Ivanov-Kholodnyy [3].

During the past decade experimental investigations of the solar X-ray radiation have been conducted in the U.S.A with the help of rockets by H. Friedman and collaborators [4]. Naturally, the experimental material available at present is comparatively small, and a further systematic research in that field with the help of rockets, and particularly of satellites is indispensable, for the latter provide the possibility of investigating the variations of the radiation in time.

In the apparatus installed by us aboard rockets, Geiger end-window photon counters were used as radiation receivers, with a window made of mica (1.6 mg/cm^2, d = 4 mm) with an aluminum coating of about 2μ. The counters were placed outside the devices' container, which was self-orienting by the Sun after its separation from the rocket. In other to shield the window from low-energy electrons, likely to impart X-ray brehmstrahlung at counters' input a magnetic system was installed so as to prevent bombardment of the window by electrons with 15-20 keV energies, and also control counters.

From the counters, pulses were transmitted to two scaling circuits. The counting rate was transmitted to the Earth by a telemetric system. The launchings were effected in morning and evening, and in both experiments the zenithal distance of the Sun was near 90^{o}.

A notable counting rate increase was registered in the Sun-oriented counters beginning with the 95 km altitude. In both cases the control counters indicated the absence of a notable number of electrons. This allows us to ascribe to solar X-ray radiation the registered data.

The readings of the operating and control counters of the second launching are plotted in Figure 1. In this experiment the control counter was turned off the Sun by 15°. The second small maximum of the counting rate corresponds to the maximum of the cosmic background.

Originating from Mikhnevich data on atmosphere density distribution by altitude [5], the results of measurements were extrapolated to the atmosphere boundary. The obtained values of the radiation flux in the 2 — 10 Å region were $7.3 \cdot 10^{-4}$ and $3.2 \cdot 10^{-4}$ erg/cm^{2}-sec. A class 1 chromospheric flare was observed during the launching of the second rocket. If we admit that the Sun's radiation in the 2 — 10 Å region of the spectrum is continous and has a retarding character with a temperature of $4.5 \cdot 10^{6\circ}$ K, the experimentally observed variation with altitude of radiation intensity is satisfactorily approximated.

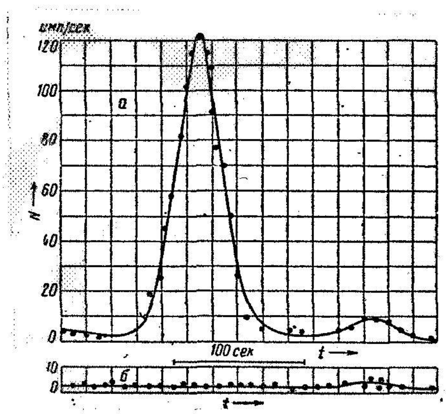

Fig. 1. Counting rate N as a function of time after rocket's takeoff.
a — readings of the Sun-oriented counter.
б — readings of the control counter.

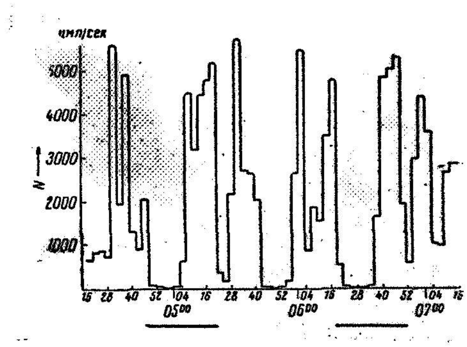

Fig. 2. Portion of the registration of counter-readings obtained on 20 Aug.1960 on the 2nd spaceship equipped with berillium windows. Time is Moscow time.

In the apparatus installed aboard the second spaceship, 6 end-window photon counters were used as radiation receivers. They were closed by windows made of beryllium 0.1 mm thick, and 7 mm in diameter. The counters were installed in the apparatus'bay in six mutually perpendicular directions. The half-width of each counter's visual field represented about 25°. The counters' windows were provided with a magnetic shielding. Pulses from all counters entered the input of the total scaling circuit, whose last stages (locations) were counted every 3 minutes by the memory device. The readings of this device for 13 spaceship's revolutions were telemetered to the Earth. Besides, the counting rate was directly telemetered at times of radio communication with the Earth.

A portion of the registration of the storage device is presented in Figure 2. Intervals during which the spaceship was in the Earth's shade are underlined in the lower part of the Figure.

On the sunny side of the orbit counters registered a substantial radiation causing counting rates of the order of several thousand pulses per second. On the shadow side of the orbit the counting rate decreases to several tens of pulses per second characterizing the cosmic background. The stepped character of the registration at the sunny side is provoked by the Sun's departure from counters' visual field.

The regions of high counting rates partially enter the shadow zone of the orbit. These portions of the orbit are basically disposed at latitudes where works by Vernov, Chudakov and Van Allen revealed protrusions of the outer radiation belt [6]. It is natural to admit that the high counting rate in the shadow portions of the orbit was caused by electron brehmstrahlung and fast-penetrating particles. It is rather difficult to separate the contribution of the Sun's X-ray radiation from the action of particles on the solar side of the orbit in the region of high and middle latitudes. As to the region of low latitudes, the analysis of registrations in the shadow portion of the orbit shows that at the height of spaceship's orbit, the radiation, dependent upon radiation belts, does not extend below 30 – 40° northern, and 20 – 30° southern latitudes. It may be admitted, as this was corroborated by the subsequent experiments on the third spaceship, that the same takes place at the solar side of the orbit. Therefore, the indications of the counters in the latitude region below 20 - 30°, may be basically ascribed to X-ray radiation of the Sun *). For the radiation flux in the 2 — 10 Å region, the magnitude 7.6 10^{-4} ergs/cm^2- sec is obtained.

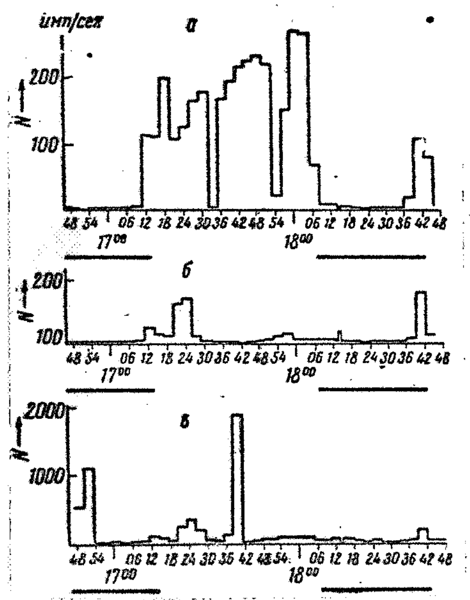

Fig. 3. Portion of entries obtained on 1 December 1960 aboard the third spaceship :
a — readings of the mica counters Sun-oriented ;
б — readings of control mica counters ;
в — readings of the beryllium counters.
All data are in pulse/sec for one counter. The time is Moscow time.

The following modifications were introduced in the apparatus installed aboard the third spaceship: two counters with a mica window (1.6 mg/cm^2, d = 4 mm), covered by two layers of aluminum foil, 5 thick, switched in parallel, were installed on self-inducing system of solar batteries of the spaceship — their axis; they thus were constantly Sun-oriented. Two similar counters were disposed on that system with axes directed perpendicularly to the direction toward the Sun. A tantalum plate at 45° angle with the direction of the Sun was disposed in front of the counters' windows. These control counters obviously registered only the X-ray radiation, appearing at electron retardation on the tantalum plate, and thus allowed to outline portions of the orbit with a notable background of electrons. Two counters with a beryllium window 0.1 mm thick with parallel axes and switched in parallel were installed in the apparatus' compartment. The counters were provided with a magnetic shielding. The scaling scheme and the registration of pulses by the storage device were as previously and consisted of three independent channels.

*) see infrapaginal note page 7.

A portion of entries is represented in Figure 3. The character of counters' entries, and namely of those Sun-oriented is the same as before, i.e. the basic radiation is concentrated on the solar side of the orbit; there is however a substantial partial radiation on the shadow side too. Under the guidance of control counter readings portions of entries of counters directed toward the Sun, and those of the compartment counters where electron interferences are strong, may be excluded. The radiation registered on portions of the orbit, free from these interferences, is due to solar X-ray radiation. The presence of dips in the counter's "6" entries, following the Sun, is due to temporary shading of the system, as was shown by the collation of these portions with the entries of solar batteries' current. The separate maxima of the counting rate obtained in the low-latitude regions on the solar side of the orbit for counters installed in the instrument compartment, correspond to the position of the Sun within the visual field of these counters. Starting from the maximum counting rate of the counters with beryllium windows, the obtained magnitude of the X-ray flux in the region 2 – 10 Å is $2.4 \cdot 10^{-4}$ ergs/cm^2 -sec. The comparison of both counters' readings gives for the electron temperature of the Sun's radiation in this spectrum region a magnitude $\sim 2 \cdot 10^6$ in the assumption, that the radiation has a retarding character. The X-ray radiation flux remained quite constant within the entire measurement range.

It must be borne in mind that the above-presented absolute estimates of energy are approximate, but valid within the limits of a possible error of the order of 2 – 3

The results of our measurements agree well with those of M. Friedman, effected during the extent of a total solar cycle. He has obtained for regions shorter than 8 Å, magnitudes between $3 \cdot 10^{-6}$ and $1.5 \cdot 10^{-3}$ ergs/cm^2 -sec.

On the basis of mica control counter readings, regions of notable amounts of electrons are outlined in the map of Figure 4.

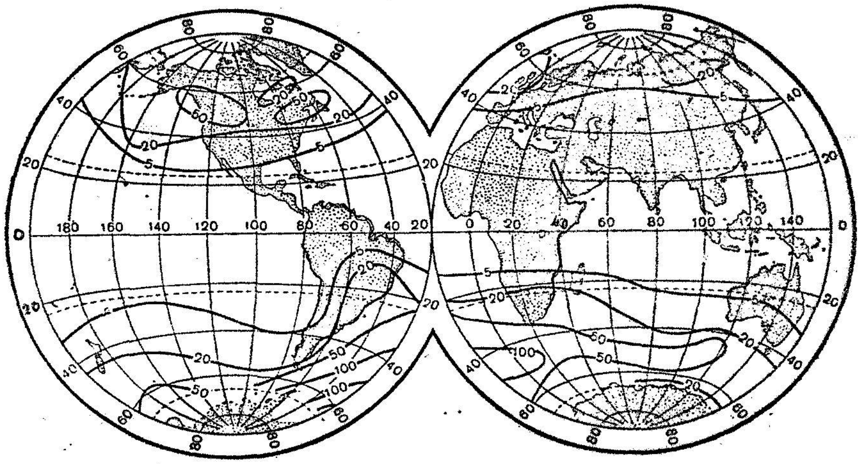

Fig. 4

Orientation map of regions with a notable corpuscular radiation according to data supplied by the control mica counters installed aboard the 3rd Soviet spaceship. The numbers over the curves indicate the counting rates in pulse/second for one counter.

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*) From page 5:
The absence of notable background from electrons in the region of low latitudes is corroborated by the fact that in certain entry portions of the direct transmission on the solar side of the orbit, the counting rate dropped as the Sun drifted away from the visual field of the counters till the cosmic background level.

As already indicated, these regions extend down to 20 – 30° latitudes. There is an anomaly, lying in the region from 35 to 50° southern latitude, and from 30.3 to about 20° eastern longitude, which was observed also in the work by L. V. Kurnosova and others [7]. The boundaries of the regions corresponding to various levels of particle count, are quite conventional, and probably inconstant in time.

**** E N D ****

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Entered on 19 April 1961

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